Appendix C

Charts of Plotted Pressure Data from Lysimeters with Performance Evaluation and Recommendations

Appendix C

Charts of Plotted Pressure Data from Lysimeters with Performance Evaluation and Recommendations

Author: Joel Hubbell

KEY TO APPENDIX

Lysimeter Pressure: The data are presented in cm of water pressure relative to the atmospheric pressure. Data are collected by Model 15 Electronic Engineering Innovations data recorder measuring over the range of –800 to +800 cm water pressure (Electronic Engineering Innovations, Las Cruces, New Mexico).

NOTES: *Many of the lysimeters respond as if there is an air leak into the instrument (fittings, tubing, or the stainless steel membrane has not been fully saturated). Techniques need to be developed to determine the source of air entry into the lysimeter.*

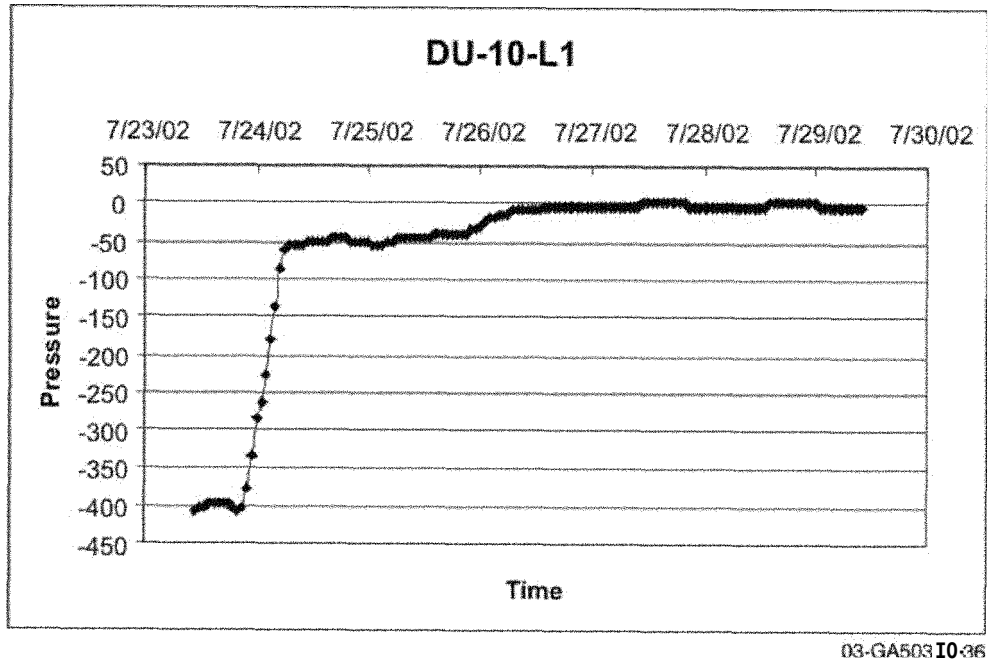

Figure C-1. DU-10-L1.

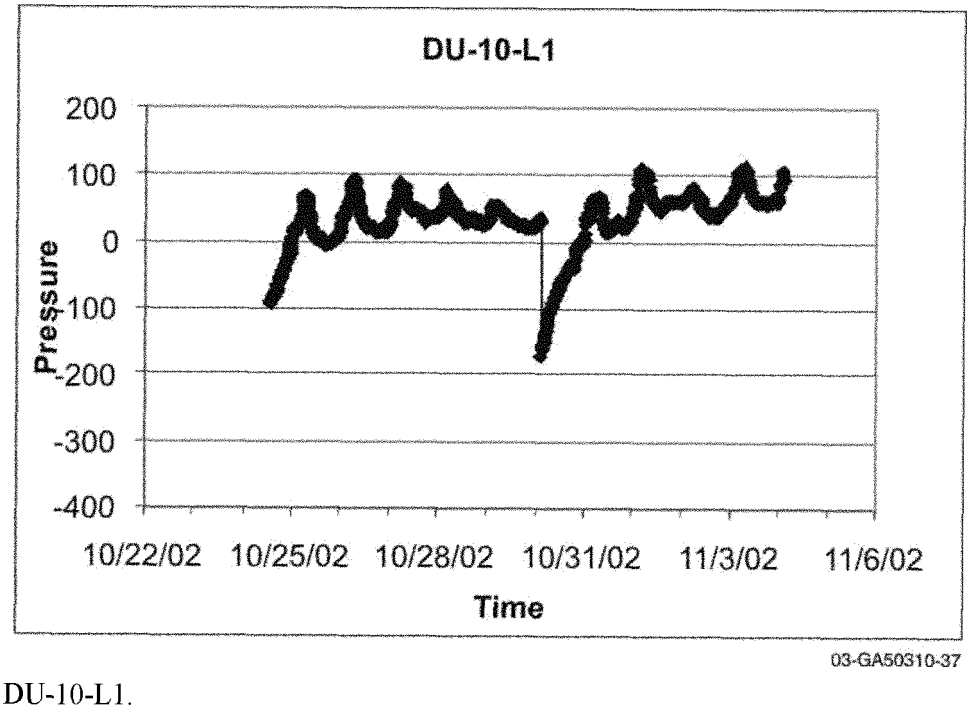

Figure C-2. DU-10-L1.

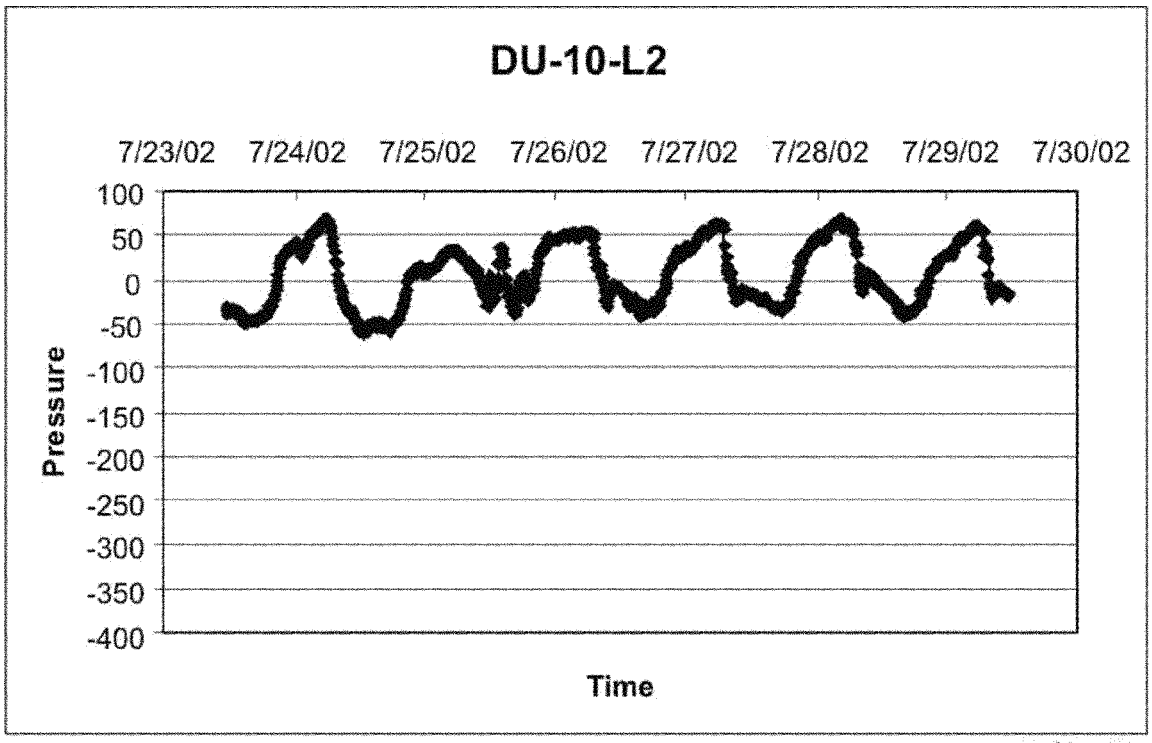

Figure *C-3.* DU-10-L2.

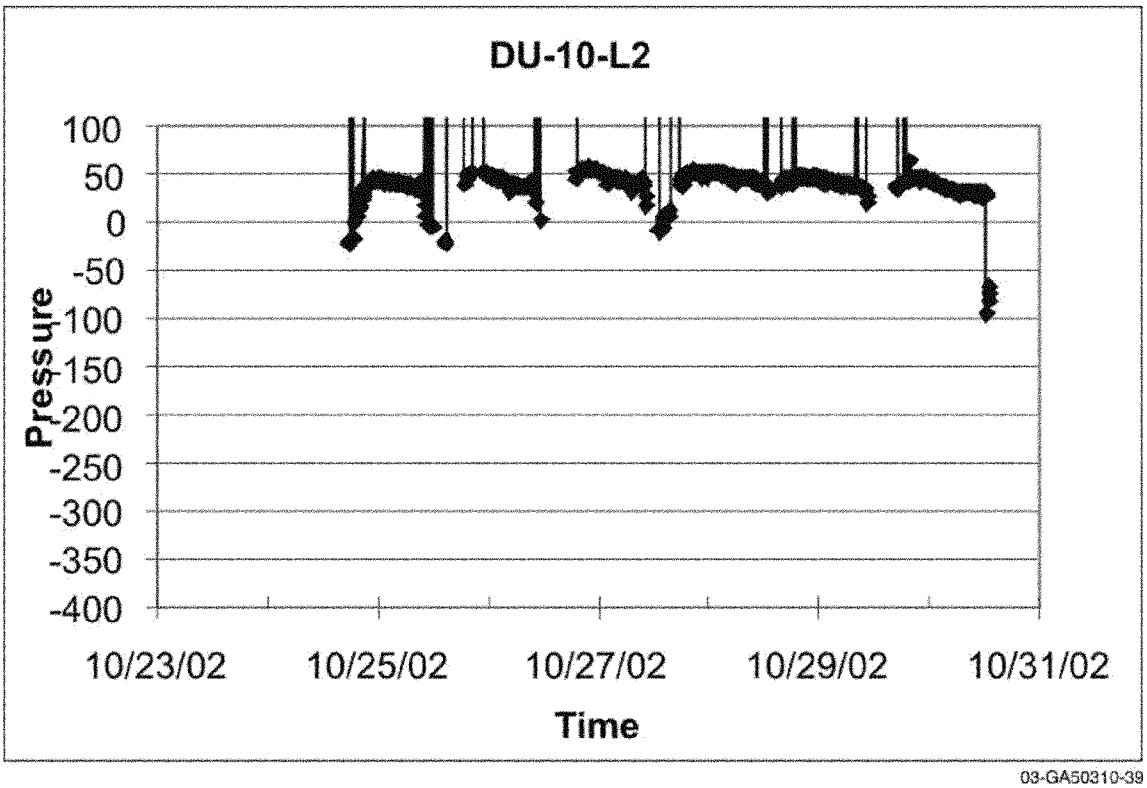

Figure C-4. DU-10-L2.

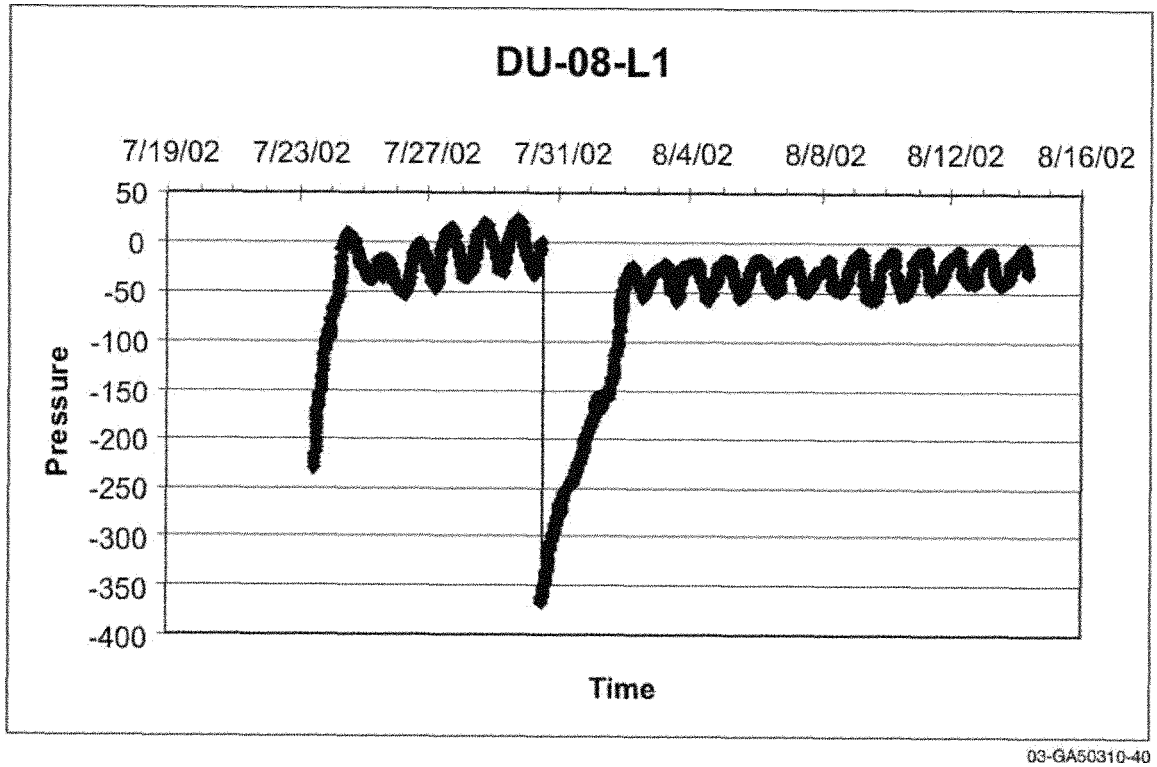

Figure C-5. DU-08-L1.

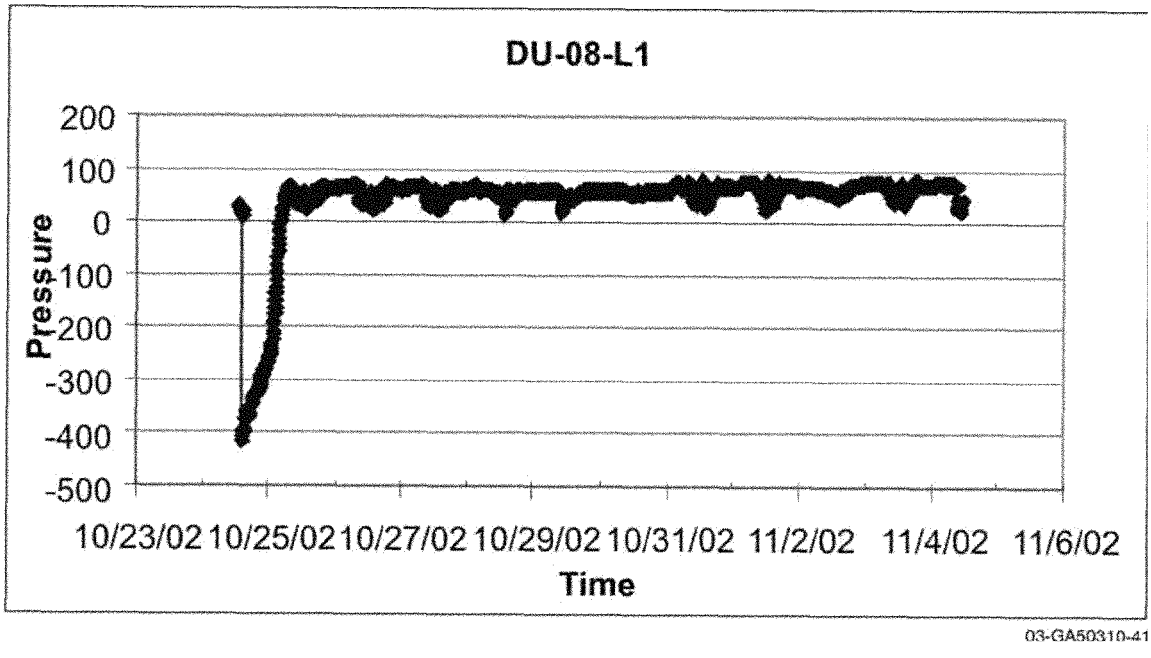

Figure C-6. DU-08-L1.

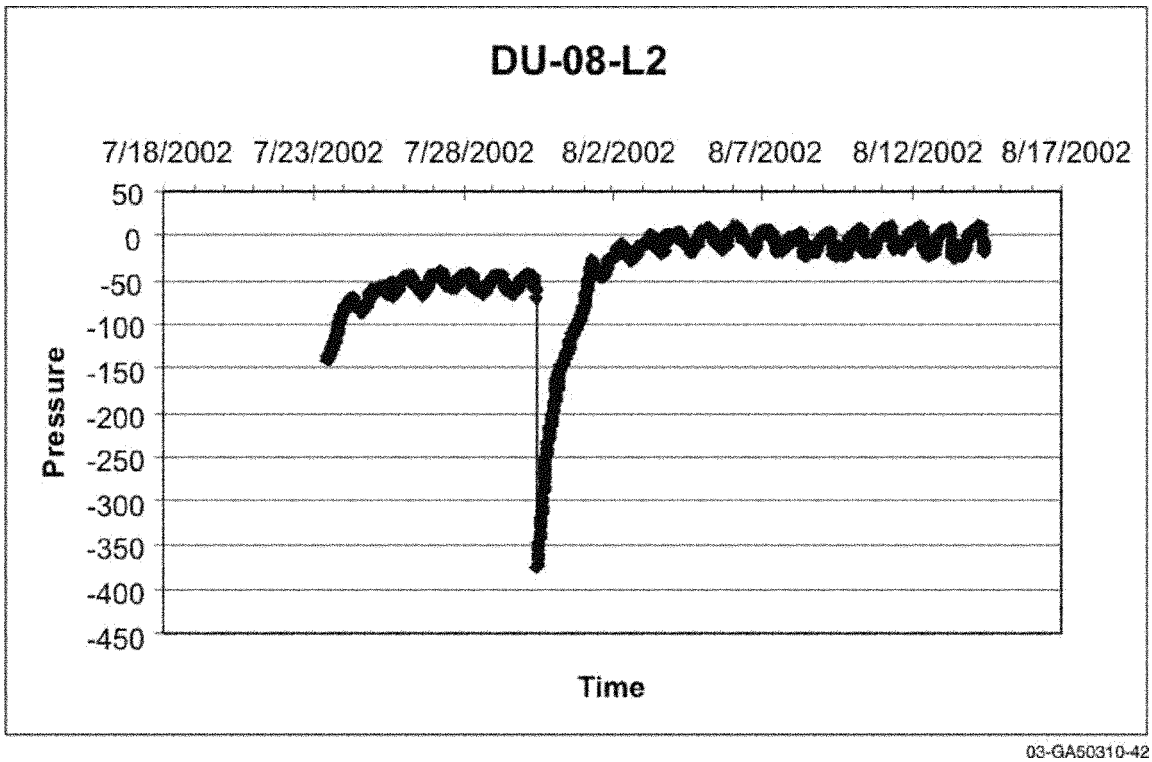

Figure C-7. DU-08-L2.

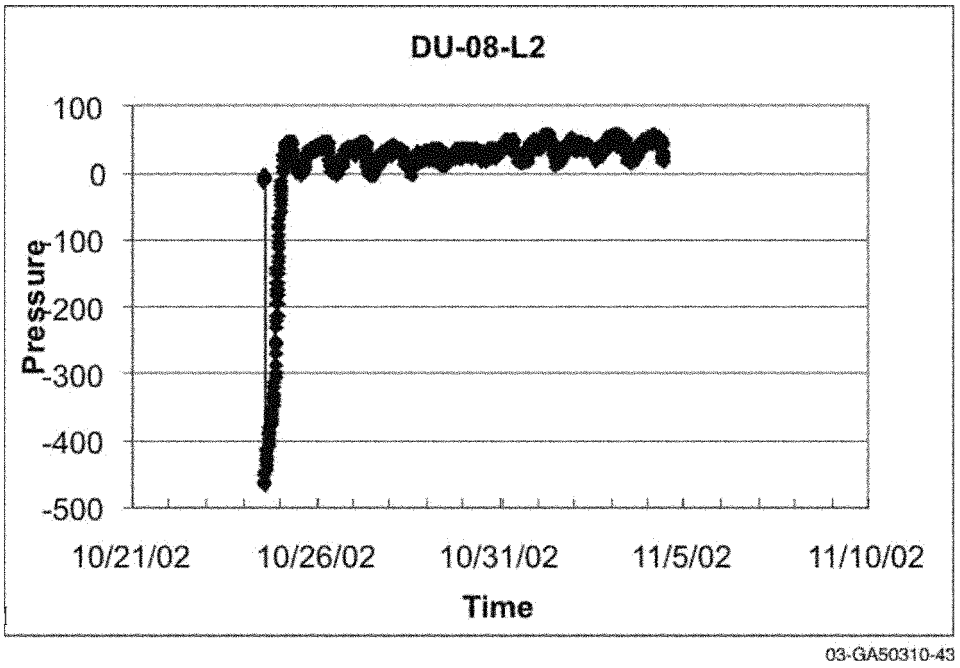

Figure C-8. DU-08-L2.

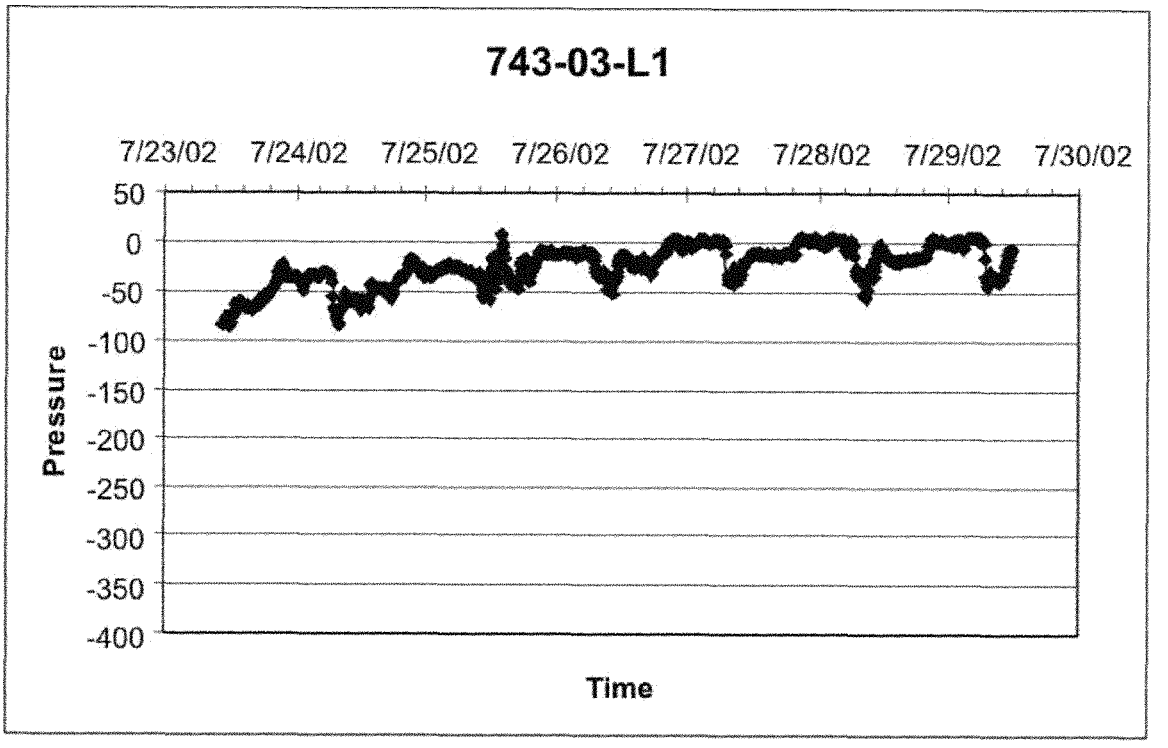

Figure C-9. 743-03-Ll.

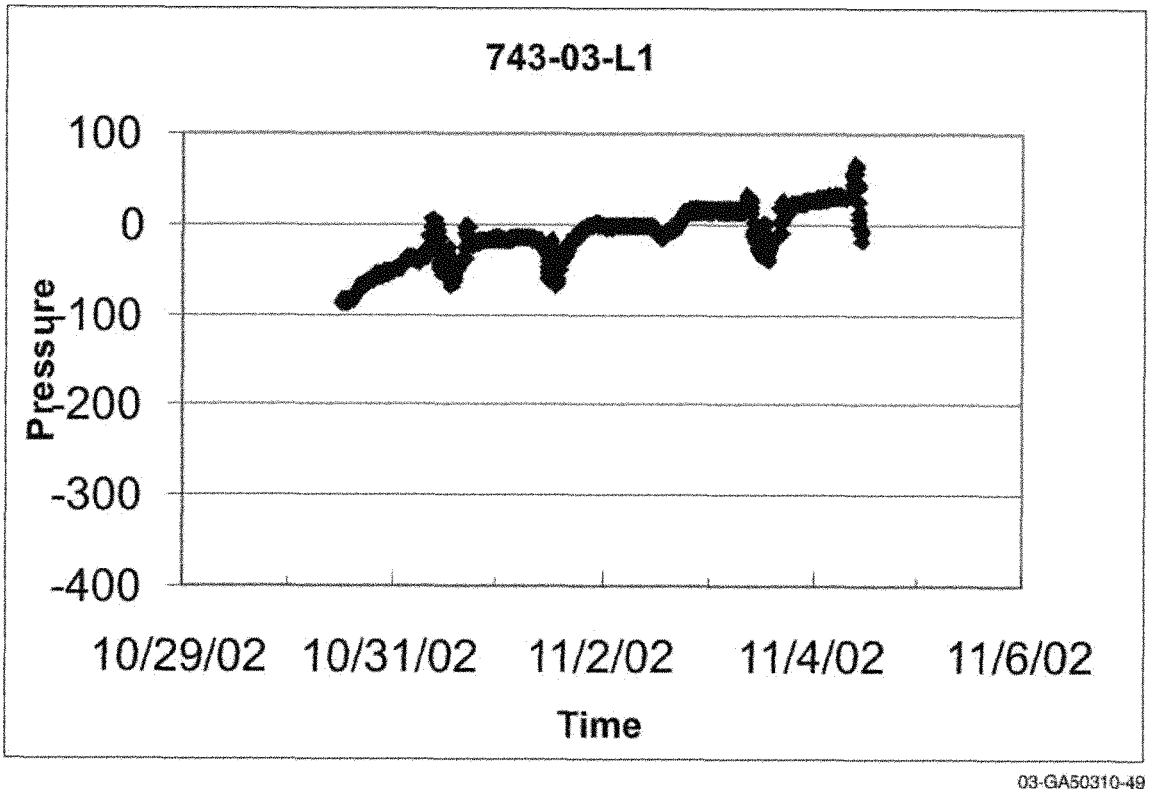

Figure C-10. 743-03-L1.

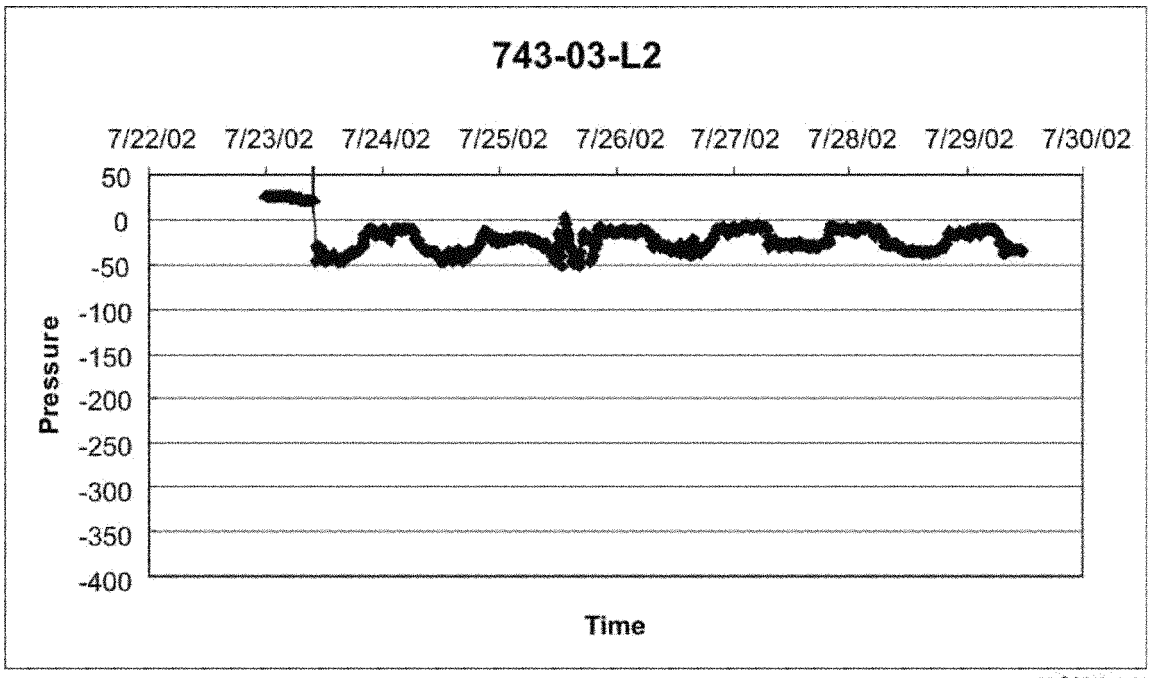

Figure C-11. 7d3-03-27.

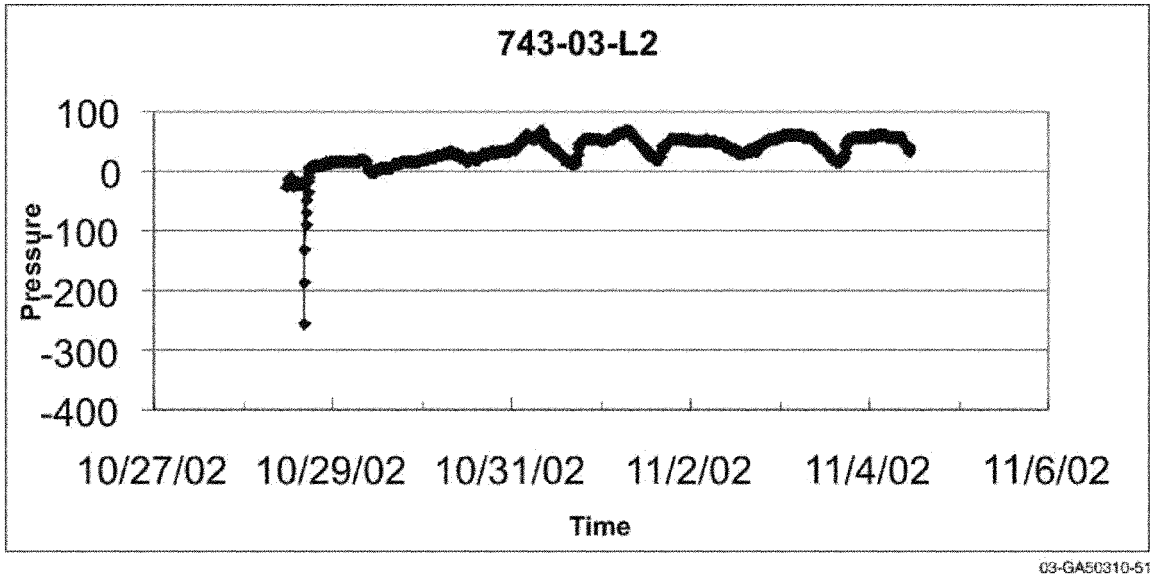

Figure C-12. 7d3-03-27.

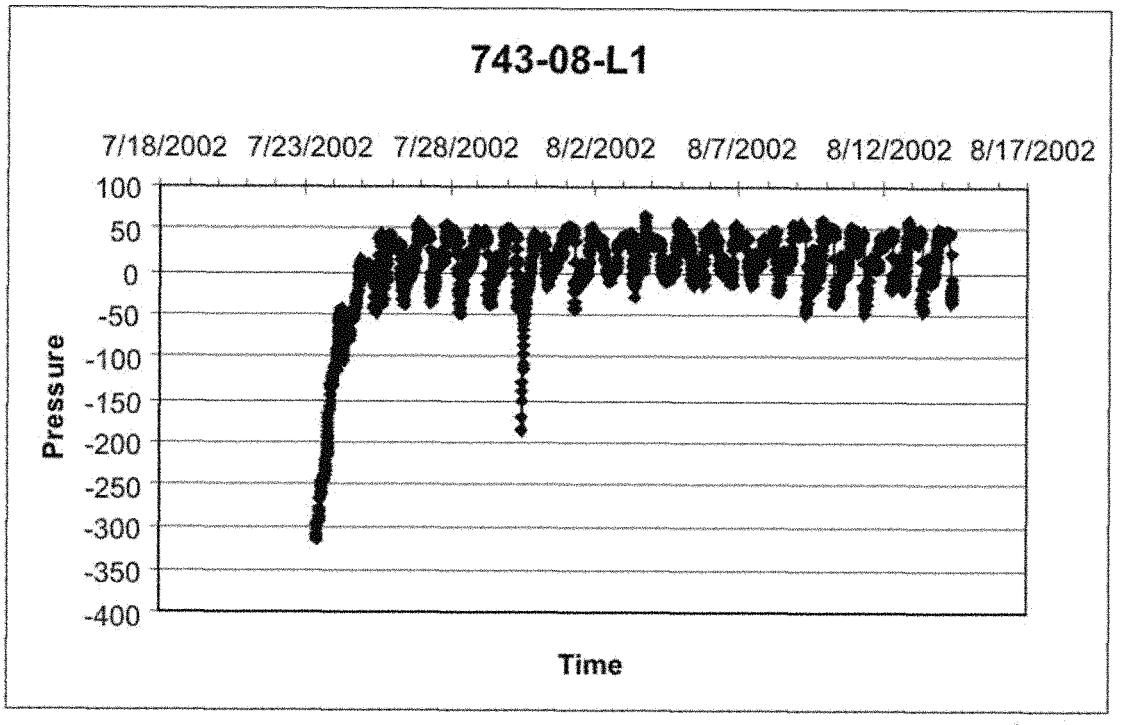

Figure C-13. 743-08-L1.

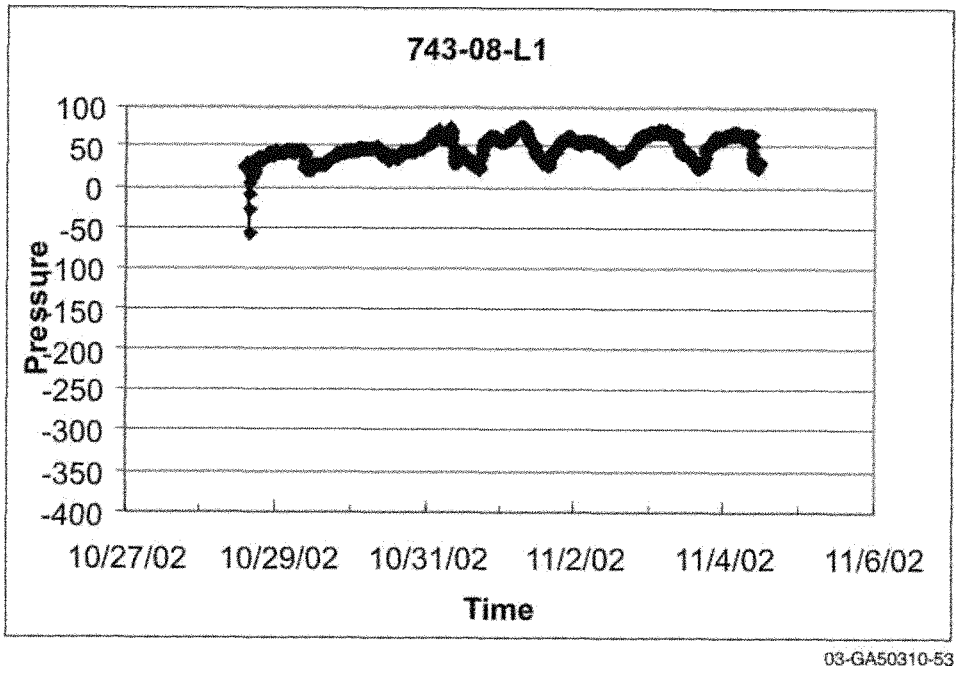

Figure C-14. 743-08-L1.

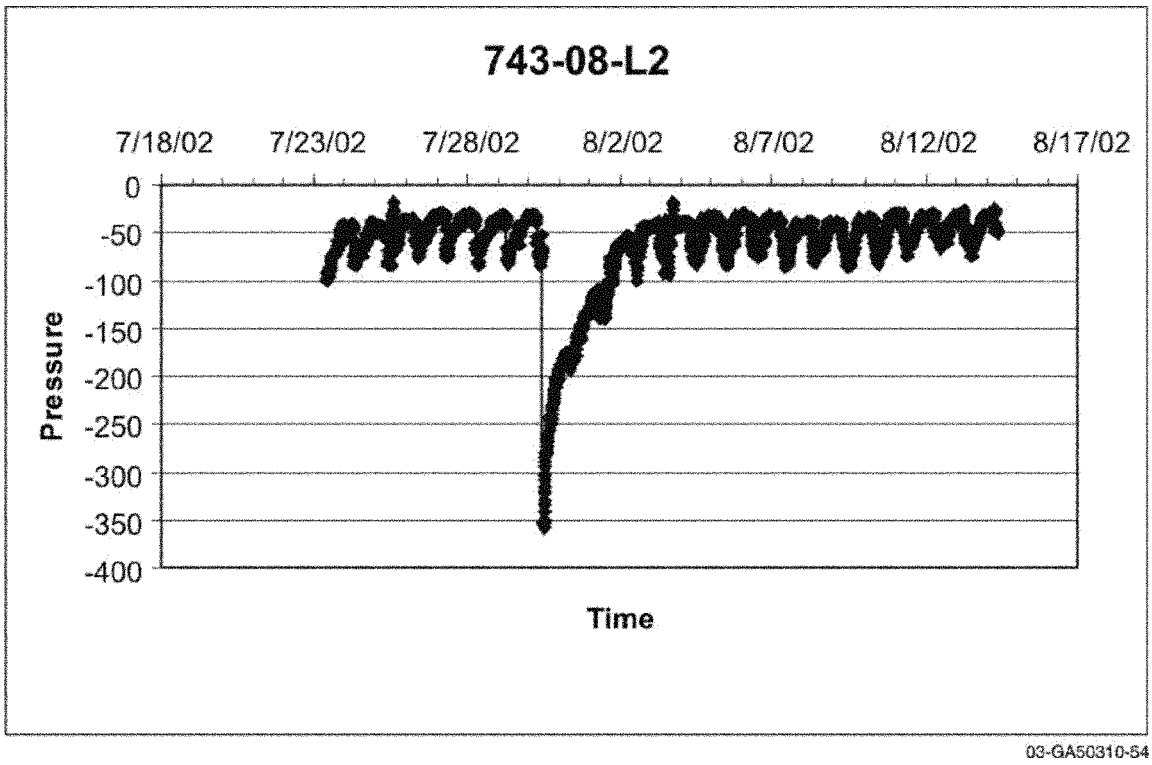

Figure C-15. 743-08-L2.

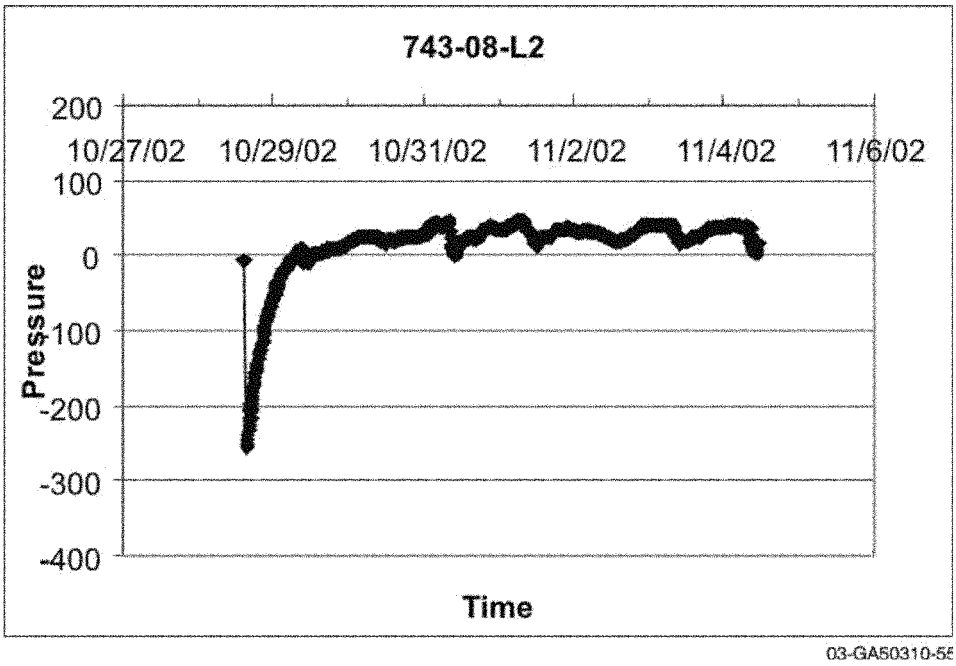

Figure C-16. 743-08-L2.

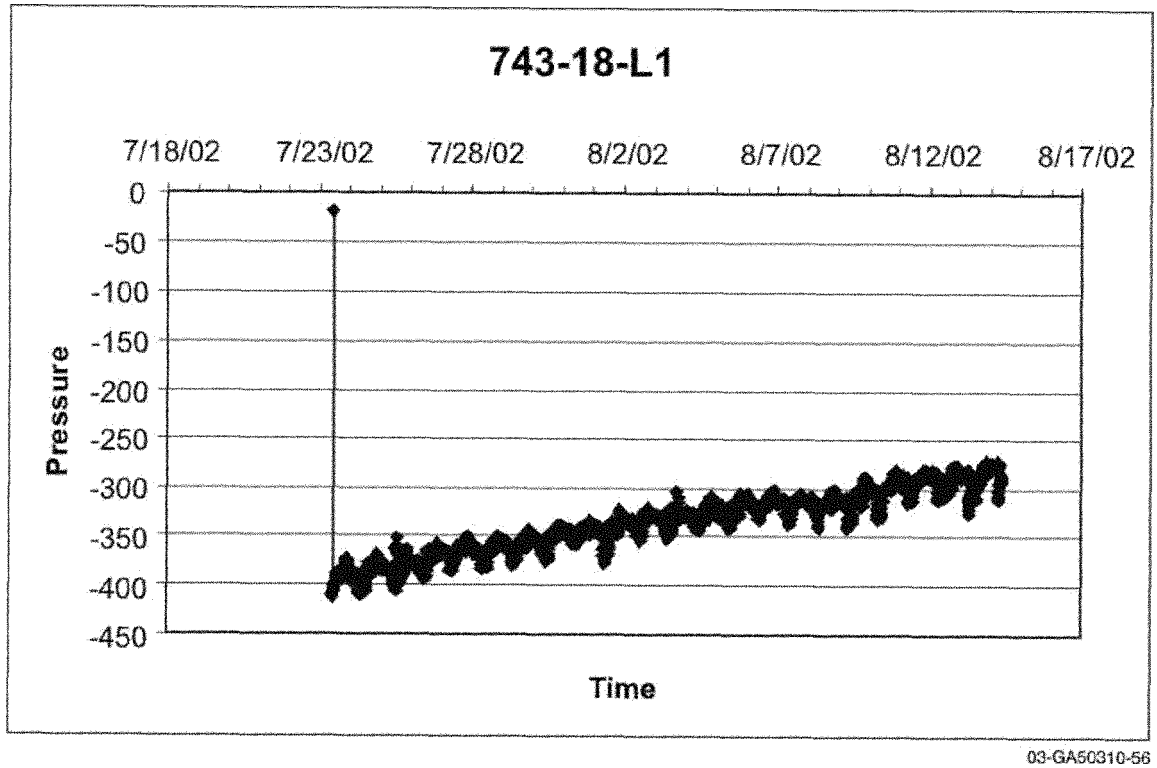

Figure C-17. 743-18-L1

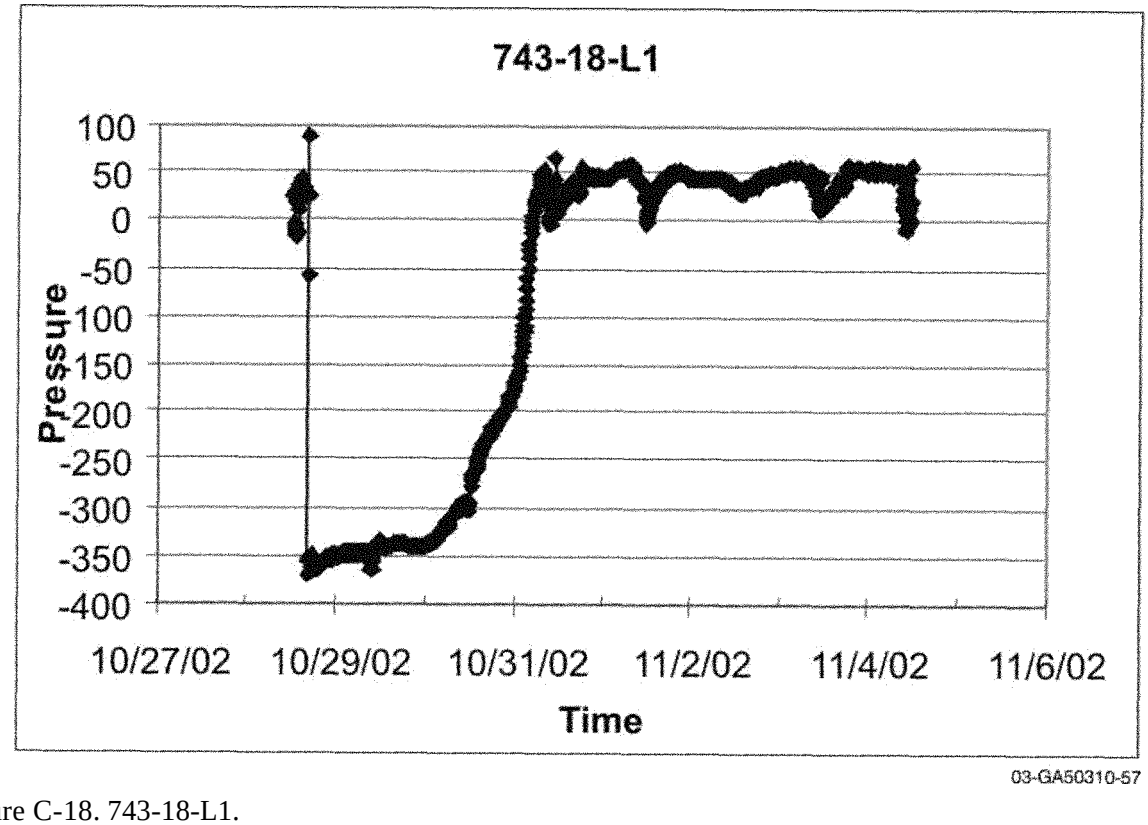

Figure C-18. 743-18-L1.

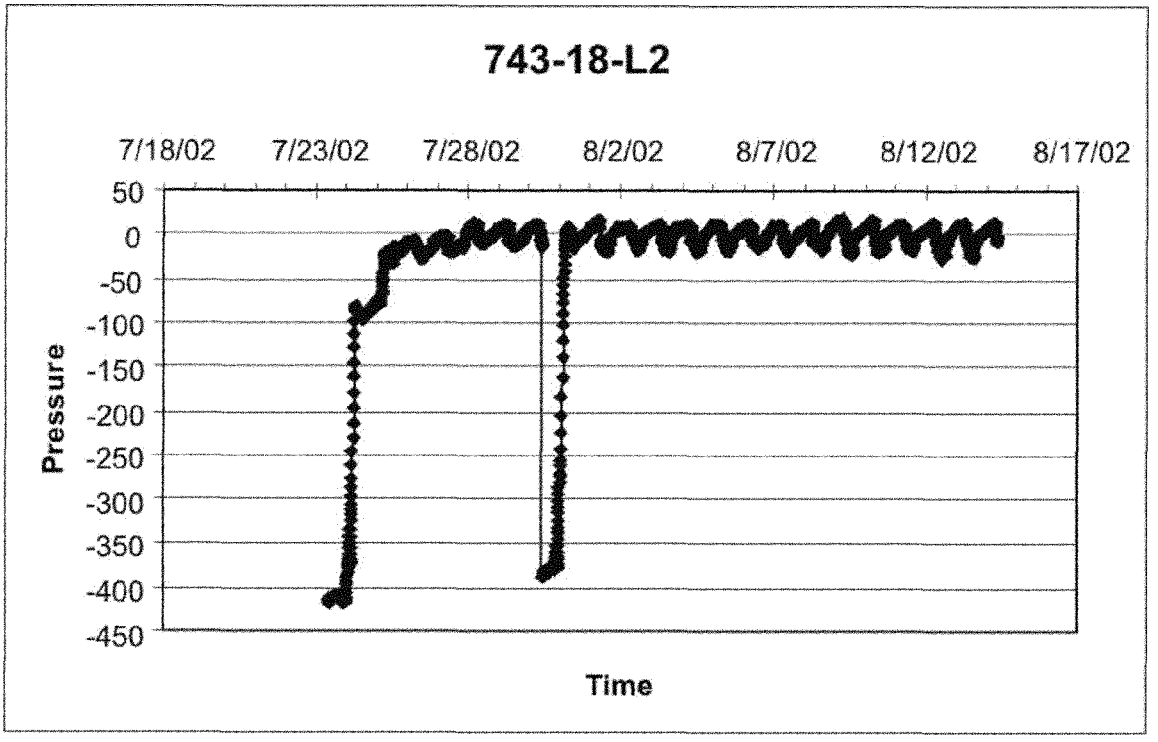

Figure C-19. 743-18-L2.

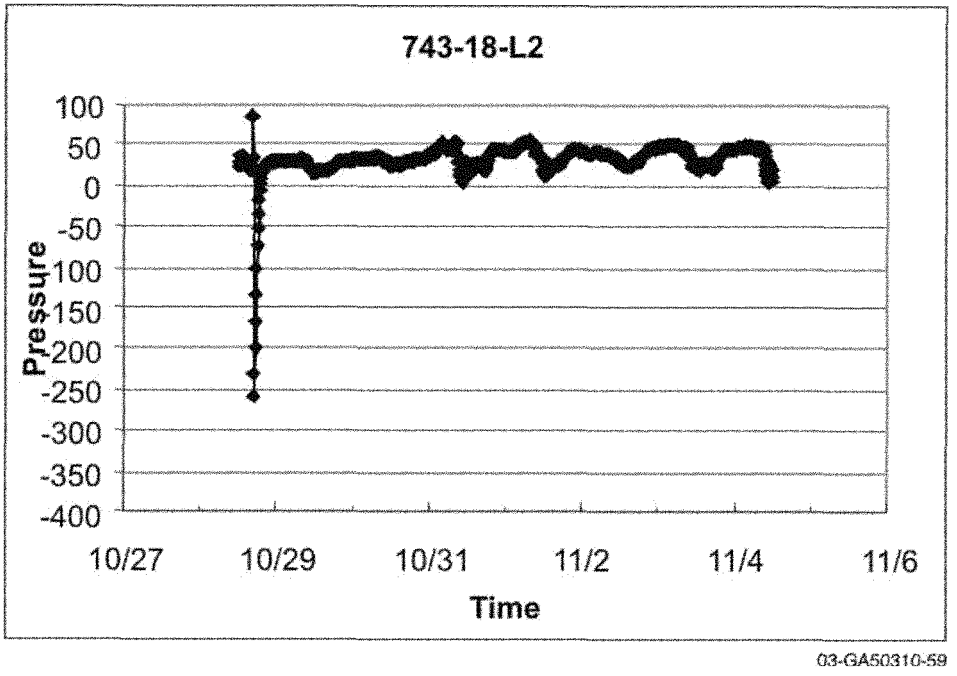

Figure C-20. 743-18-L2.

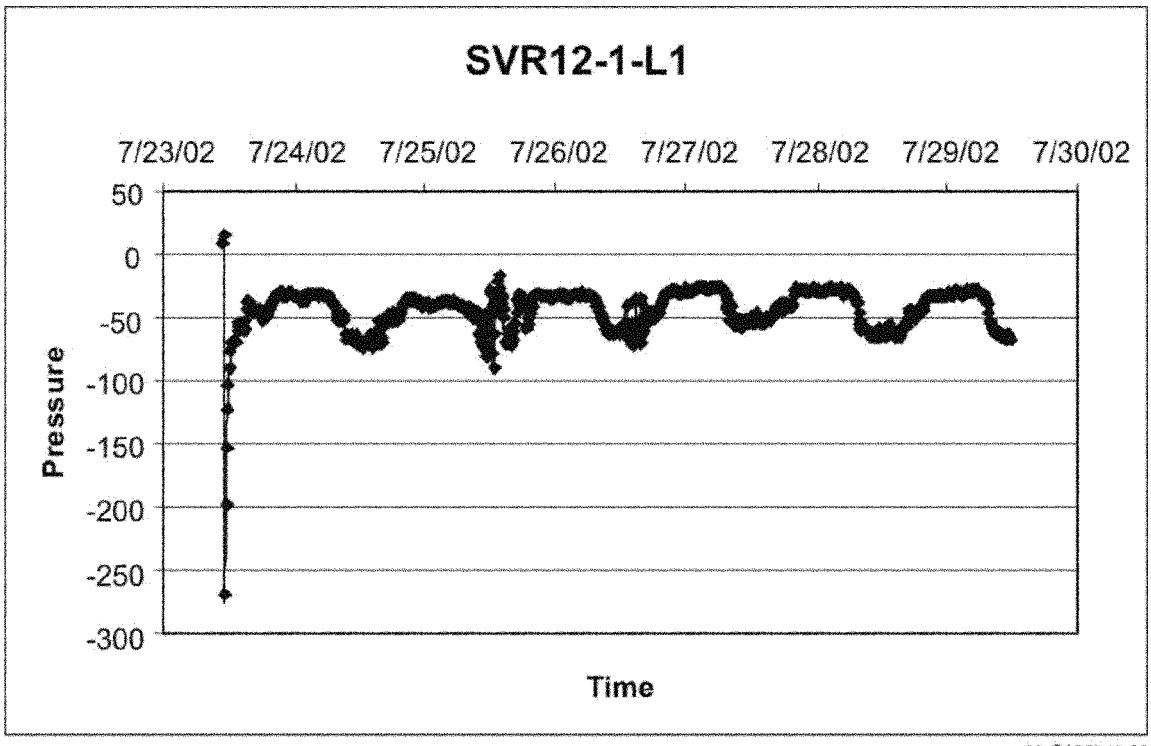

Figure C-21. SVR-12-1-L1.

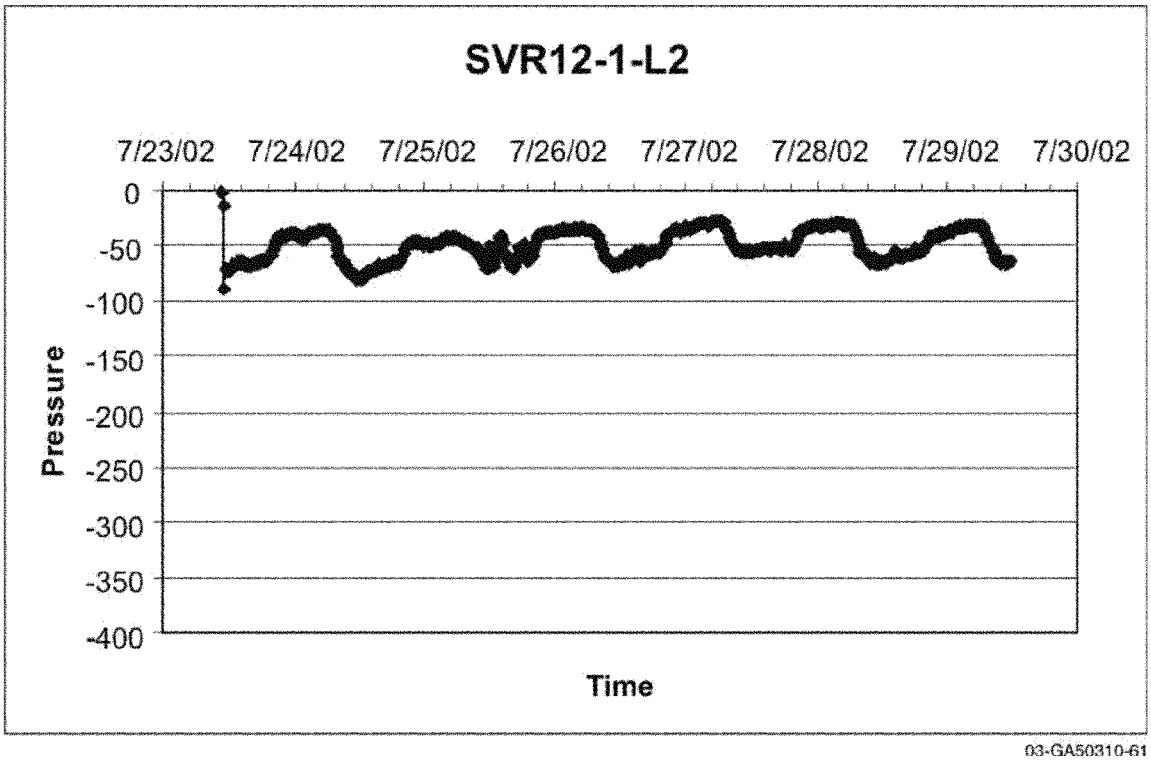

Figure C-22. SVR-12-1-L2.

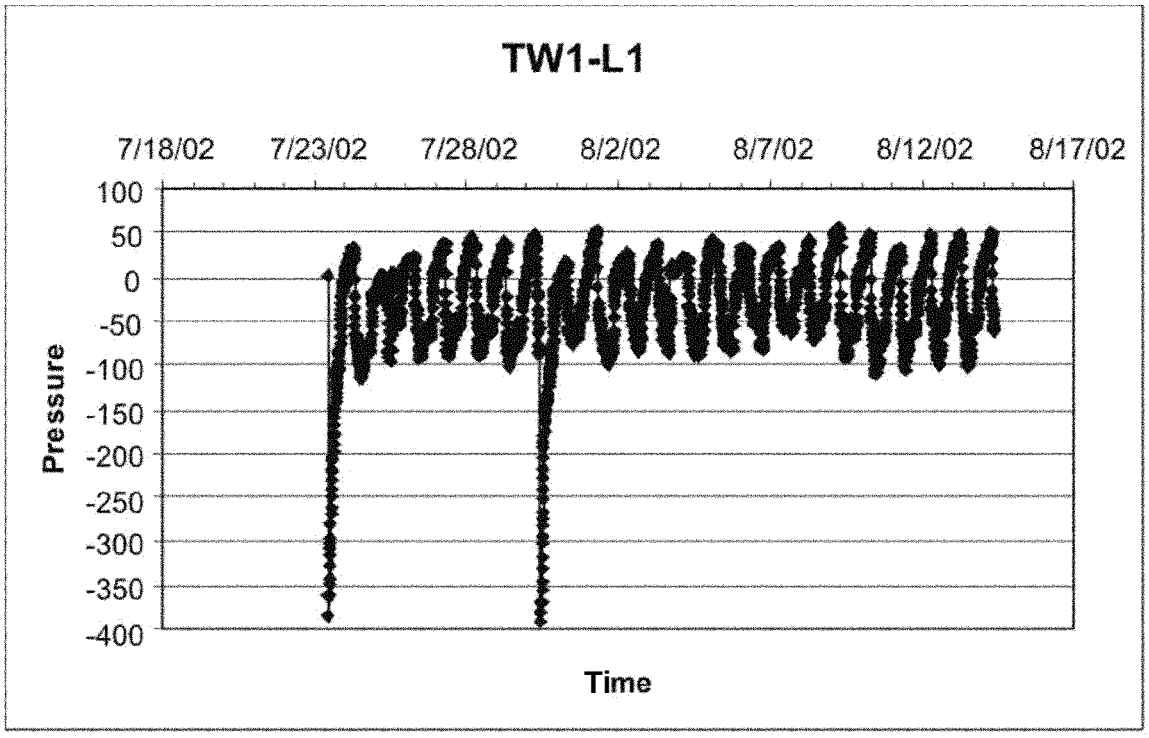

Figure C-23. TW-1-L1.

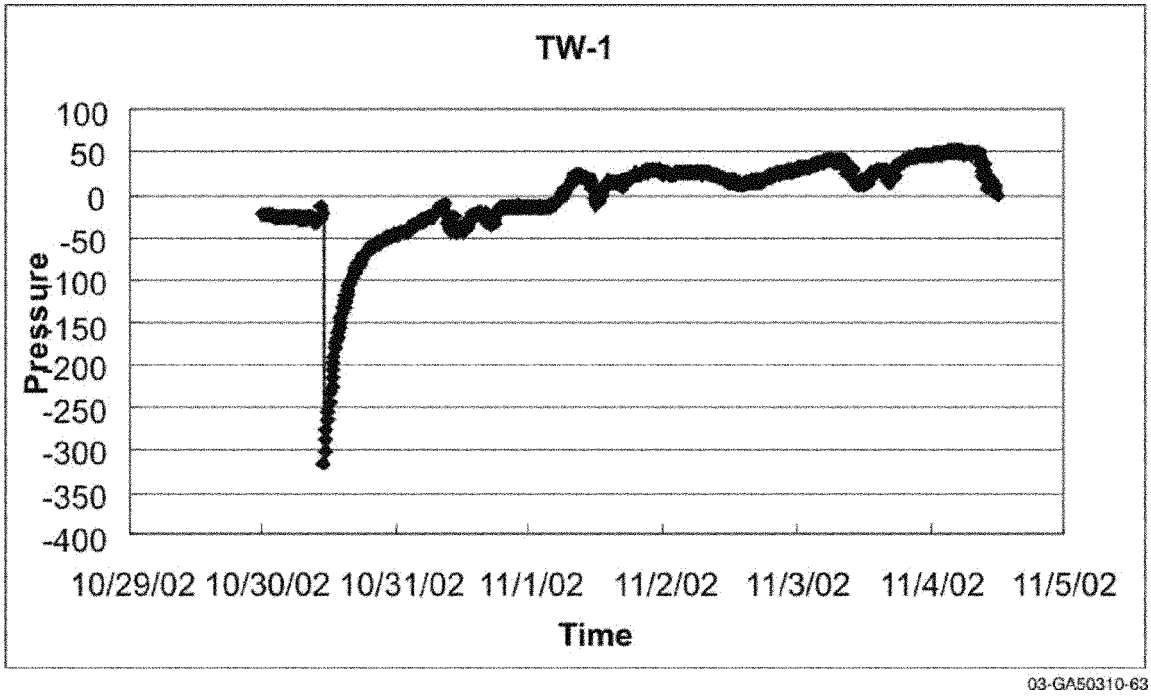

Figure C-24. TW-1.

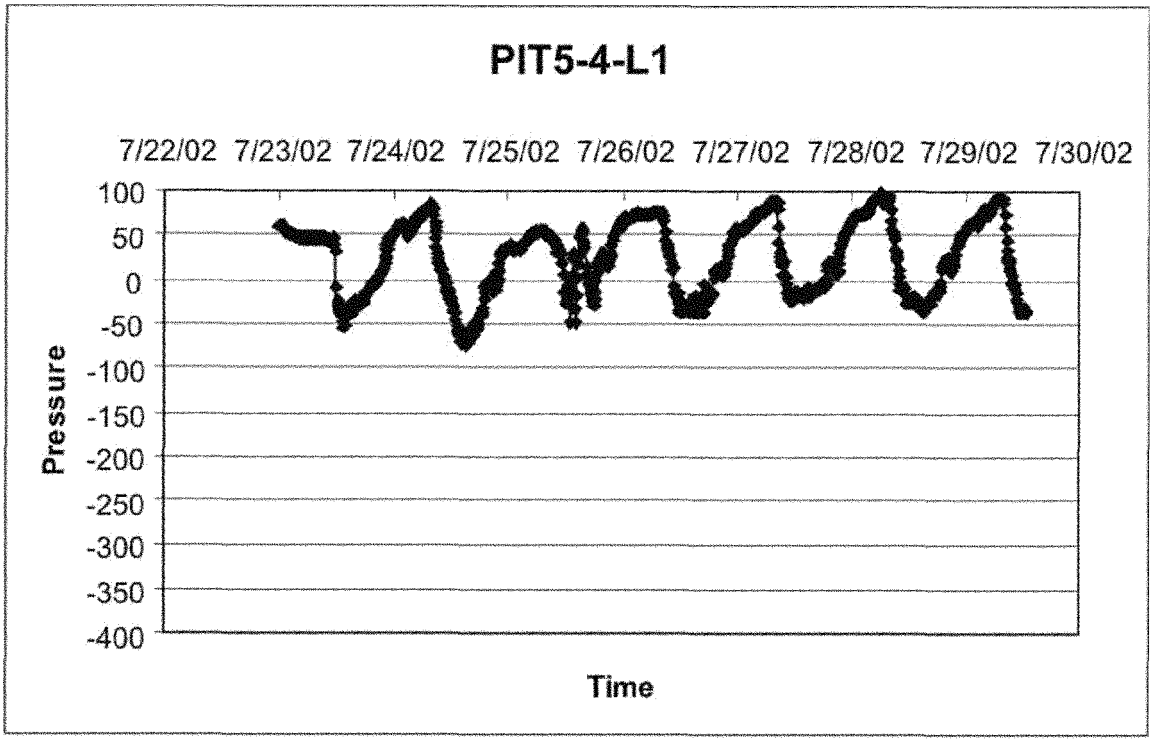

Figure C-25. Pit5-4-L1.

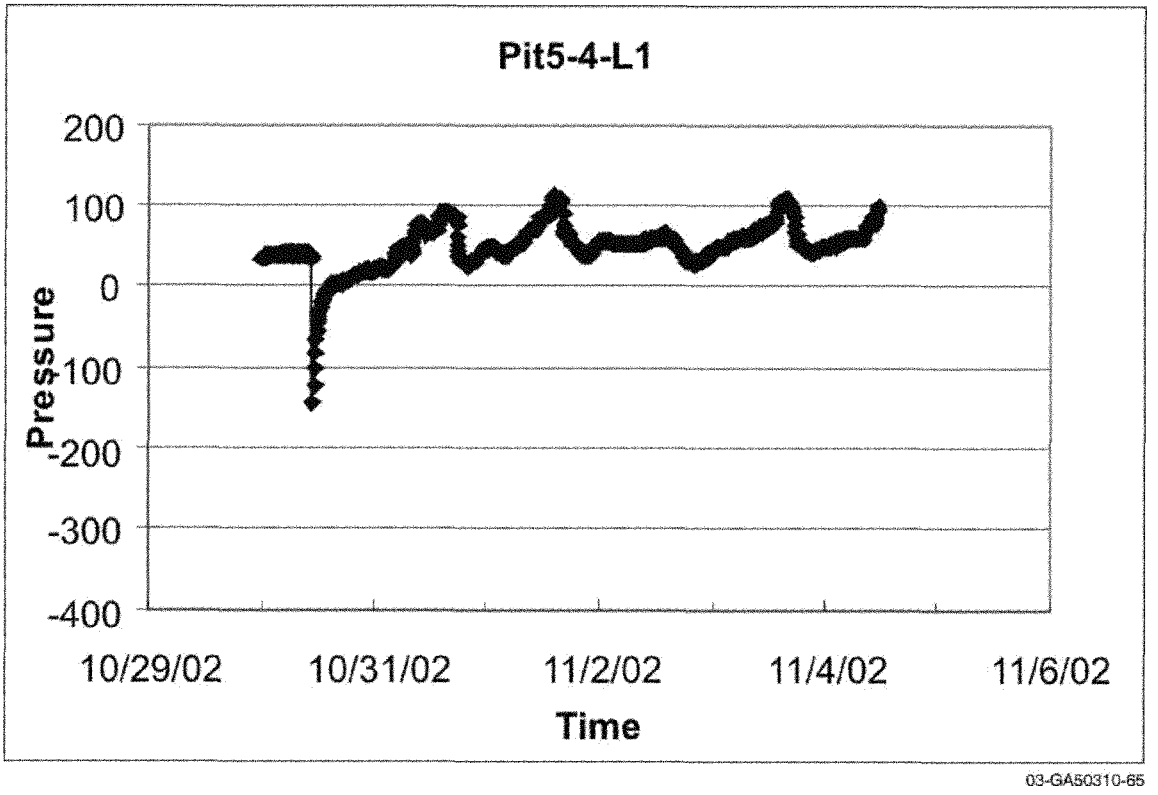

Figure C-26. Pit5-4-L1

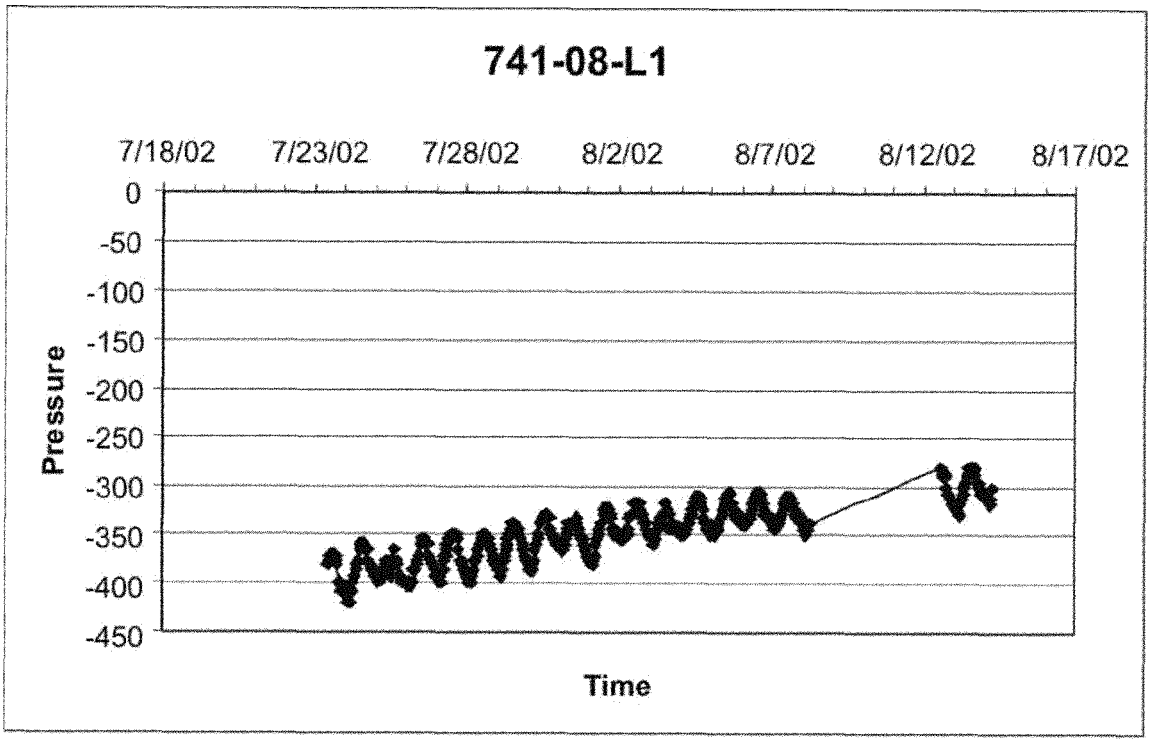

Figure C-27. 741-08-L1.

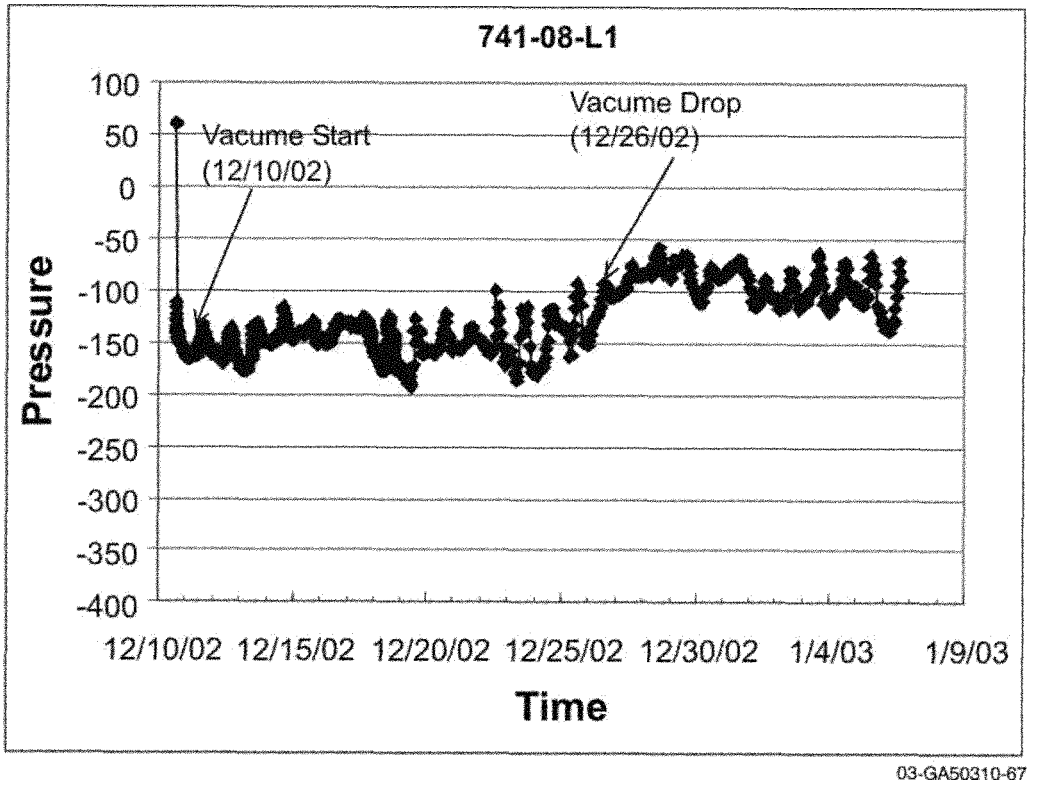

Figure C-28. 741-08-L1.

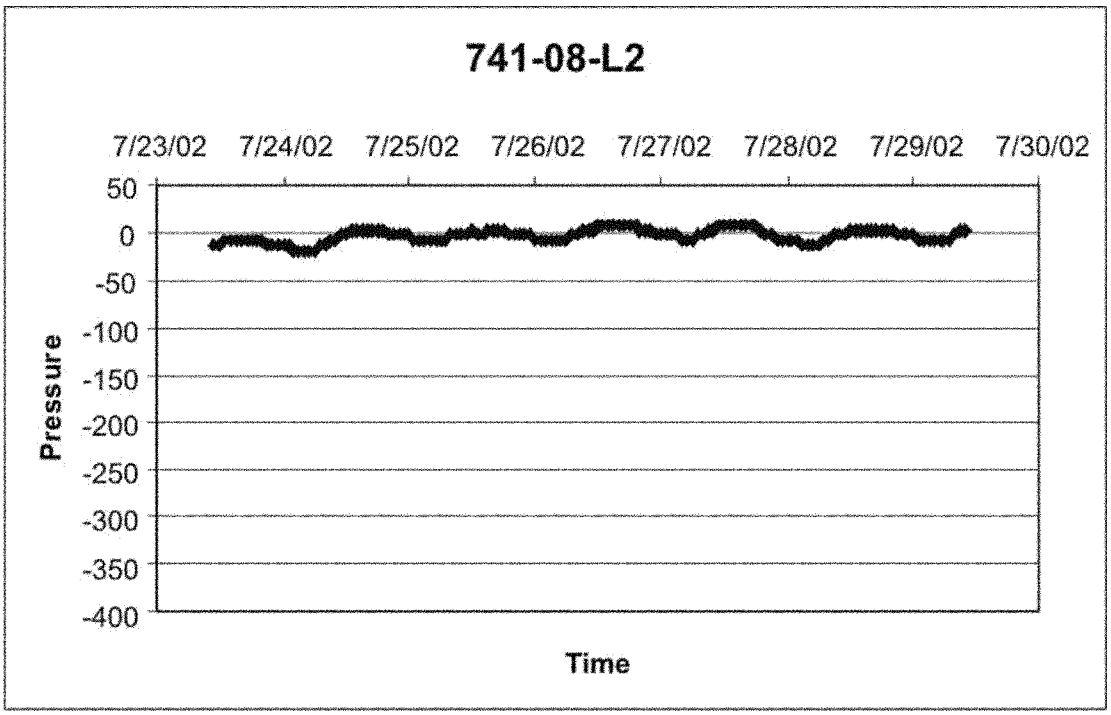

Figure C-29. 741-08-L2.

Appendix D

Modes of Failure from Lysimeters

Appendix D

Modes of failure from lysimeters

Author: Joel Hubbell

D-1. ASSUMPTIONS

This evaluation assumes a single mode of failure to collect water samples from the solution samplers and not multiple problems. The pressure data, while sampling, suggest that the porous stainless steel **(SS)** was not fully wetted up when inserted, that the water was displaced from the **SS** membrane by the sonic vibration, or that there are leaks in the system.

D-2. TEST PROCEDURES

Vacuum Test: Apply vacuum below air entry pressure, and record pressure with a pressure transducer at land surface. If the device has previously collected samples, use a 1/2-hour scan and run for 2 weeks or sufficient time so that the pressure is not dropping further. If no water has been collected and there was a rapid drop in pressure, collect pressure measurements at a 1-to-5-minute interval. The suction lysimeter design limits the full diagnosis of the problem.

Positive Pressure Test: Seal both lines and apply pressure (–10 psi) for about 36 hours. Record pressure at time increments of about 5-10 minutes. A positive pressure test could be performed that would indicate if there are mechanical problems (leaks) above the check valve (or check valve is stuck open or closed).

D-3. POTENTIAL SUCTION LYSIMETER PROBLEMS

- Porous **SS** not fully saturated with water (may be caused by vibration having dewatered the porous membrane or drying of the membrane before insertion).

  Result: Air flows through porous **SS,** so no water is collected. Pressure drops quickly.

  Vacuum test: Vacuum drops quickly

  Positive pressure test: Pressure test indicates no leakage in lines or check valve. Look at adjacent tensiometers for ambient soil water pressure.

  Solution: Wait for site to wet up following spring infiltration. Pond water around site to allow sampling. On new instruments, omit the check valve to allow wetting of the porous membrane following insertion. A test of this scenario suggests that the membrane will slowly wet when in contact with moist soil over time, but after about 5 months, it is still only holding about 160 cm of tension.

- Air leaks at connectors or through tubing.

  Observable result: Pressure drop to near zero pressure. Little or no water collection.

  Vacuum test: Vacuum drop at any pressure.

Positive pressure test: Pressure drop over time.

Solution: Connect large volume air tank or vacuum pump to increase time vacuum is applied

- Sediment to dry to sample quickly (—-300 to -550 cm pressure).

  Observable result: Water collected very slowly.

  Vacuum test: Vacuum drops very slowly

  Positive pressure test: Pressure test indicates no leakage in lines or check valve. Look at data from adjacent tensiometers to determine if site may be dry.

  Solution: Apply vacuum for an extended time period. Anticipate very small samples.

- Sediment soil water potential exceeds –550 cm pressure.

  Result: The porous membrane does not have enough moisture to prevent air moving through the membrane. Air flows through porous **SS,** so no water is collected. Pressure drops quickly.

  Vacuum test: Vacuum drops quickly.

  Positive pressure test: Pressure test indicates no leakage in lines or check valve. Look at adjacent tensiometers for ambient soil water pressure.

  Solution: Wait for site to wet up following spring infiltration. Pond water around site to allow sampling.

- Instrument damage during installation (broken seal at porous **SS** connection, fittings, tubing, or body of instrument).

  Vacuum test: Rapid drop in vacuum as any starting pressure approaches zero

  Positive pressure test: No pressure drop, assuming check valve functional.

  Solution: Abandon instrument.

- Excessive vacuum applied over porous **SS** during sampling (at any time).

  Result: Air entry pressure reduced on **SS,** air leakage through porous **SS** is reduced or there is no water.

  Vacuum test: Vacuum drops quickly over time — might stabilize at a lower air entry pressure of **SS.**

  Positive pressure test: No pressurize drop over time.

- Sediment around porous membrane of lysimeter site oil wet.

  Result: Soil or waste is saturated with oil, so water does not easily move into sediments and cannot enter water wetted porous **SS.**

  Vacuum test: Vacuum does not drop

Positive pressure test: Pressure test indicates no leakage in lines or check valve. Look at adjacent tensiometers for no pressure drop following activation? Unknown response. Look at televiewer log and gas-sampling results (gas conc. >10% gas solubility).

Solution: Unknown

- Check valve doesn't open, so no differential pressure over porous SS.

  Observable Result: No water collected, no pressure drop while sampling.

  Vacuum test: No vacuum drop over time.

  Positive pressure test: No pressurize drop over time.

  Solution: Abandon instrument.

- Check valve doesn't close allowing air flow to lower chamber when sampling, so water displaced from SS membrane

  Observable result: Perhaps none. Might drive water out of lower chamber and force air through porous SS, so it would not collect samples following this event.

  Vacuum test: Standard vacuum drop over time or pressure decline to low pressure

  Positive pressure test: Pressure drop over time and then stops to slow drop when water depleted in lower reservoir.

  Solution: Apply minimal vacuum pressure for short time periods to withdraw water samples.

  Solutions: Use vacuum tank to compensate for small leaks. Use vacuum pump at constant pressure for large leaks.

D-4. MISCELLANEOUS INFORMATION

Compare data from nearby tensiometer to lysimeter (where available). Soil water potential readings in sediments below the waste in the moisture monitoring area and 741-08 are in the -100-cm range while the pressure at 743-03 is about –350 cm above the basalt.

Record pressure while applying a low vacuum and then increase pressure differential over time (10 minutes) to check for low air entry pressure through SS. (This indicates that instruments are not fully saturated.) Start with pressures of about +30 cm and increase up to about 350 cm or until the pressure starts to drop immediately.

Appendix E

Summary of Sampling Results from Suction Lysimeters

Appendix E

Summary of Sampling Results from Suction Lysimters

Probe Location	Probe Type	Probe Depth (ft)	Data Logger #	Date Vacuum	Date Sampled	End Pressure*	Sample ID	Lysimeter Water (Y or N)
743-18-L1	Lysimeter	12.9			07/10/01	NA	NS	N
743-18-L2	Lysimeter	12.9			07/10/01	NA	NS	N
DU-10-L1	Lysimeter	10.1			07/25/01	NA	NS	N
DU-10-L2	Lysimeter	7.3			07/18/01	NA	Only 11.5-in. Hg vacuum could be placed on lysimeter. Probe will not hold pressure.	N
743-03-L1	Lysimeter	12.9			07/18/01	NA	NS	N
743-03-L2	Lysimeter	9.9			07/18/01	NA	NS	N
DU-08-L1	Lysimeter	16.1			07/30/01	NA	NS	N
DU-08-L2	Lysimeter	14.4			07/30/01	NA	NS	N
741-08-L1	Lysimeter	15.6			07/30/01	NA	NS	N
741-08-L2	Lysimeter	8.0			07/24/01	NA	Only 8.25 in. Hg vacuum could be placed on lysimeter. Probe will not hold pressure.	N
SVR12-1-L1	Lysimeter	11.6			08/22/01	NA	IPL001013A	Y (~20 mL)
SVR12-1-L2	Lysimeter	6.1			08/22/01	NA	IPL002013A	Y (~10 mL)
Pit5-TWI-L1	Lysimeter	12.3			08/27/01	NA	NS	N
Pit5-4-L1	Lysimeter	10.7			08/27/01	NA	NS	Trace droplets
743-08-L1	Lysimeter	23.9			09/04/01	NA	NS	N
743-08-L2	Lysimeter	9.5			09/04/01	NA	IPL003013A	Y (~10 mL)
DU-14-L1	Lysimeter	16.3			09/05/01	NA	NS	Trace droplets

Table E-1. (continued).

Probe Location	Probe Type	Probe Depth (ft)	Data Logger #	Date Vacuum	Date Sampled	End Pressure"	Sample ID	Lysimeter Water (Y or N)
DU-14-L2	Lysimeter	8.2			09/05/01	NA	IPL004013A	Y (~5 mL)
Quarterly Sampling (Fall 2001)								
DU-10-L1	Lysimeter	10.1		10/17/01	10/22/01	NA	NS	N
DU-10-L2	Lysimeter	7.3		10/17/01	10/22/01	NA	NS	N
DU-08-L1	Lysimeter	16.1		10/17/01	10/22/01	NA	NS	N
DU-08-L2	Lysimeter	14.4		10/17/01	10/22/01	NA	NS	N
DU-14-L1	Lysimeter	16.3		10/16/01	10/22/01	NA	IPL005013A	~2mL
DU-14-L2	Lysimeter	8.2		10/16/01	10/22/01	NA	NS	Trace droplets
743-03-L1	Lysimeter	12.9		10/18/01	10/24/01	NA	NS	N
743-03-L2	Lysimeter	9.9		10/18/01	10/24/01	NA	NS	N
743-08-L1	Lysimeter	23.9		10/18/01	10/24/01	NA	NS	N
743-08-L2	Lysimeter	9.5		10/18/01	10/24/01	NA	NS	N
743-18-L1	Lysimeter	12.9		10/18/01	10/24/01	NA	NS	N
743-18-L2	Lysimeter	12.9		10/18/01	10/24/01	NA	NS	N
SVR12-1-L1	Lysimeter	11.6		10/29/01	11/07/01	NA	NS	Trace droplets
SVR12-1-L2	Lysimeter	6.1		10/29/01	11/07/01	NA	NS	Trace droplets
Pit5-TWI-L1	Lysimeter	12.3		10/30/01	11/07/01	NA	NS	Trace droplets
Pit5-4-L1	Lysimeter	10.7		10/30/01	11/07/01	NA	NS	N
741-08-L1	Lysimeter	15.6		10/29/01	11/07/01	NA	IPL006013A	–20 mL
741-08-L2	Lysimeter	8.0		10/29/01	11/07/01	NA	NS	Trace droplets
Quarterly Sampling (Spring 2002)								
Probe	Instrument	Port Depth						
DU-10-L1	Lysimeter	9.8	K	04/17/02	04/29/02	Logger	NA	N
DU-10-L2	Lysimeter	7.0	K	04/17/02	04/29/02	Logger	NA	N
DU-14-L1	Lysimeter	16.0	NA	04/17/02	04/29/02	8 cb	NA	N

Probe Location	Probe Type	Probe Depth (ft)	Data Logger #	Date Vacuum	Date Sampled	End Pressure*	Sample ID	Lysimeter Water (Y or N)
DU-14-L2	Lysimeter	7.9	NA	04/17/02	04/29/02	6 cb	NA	N
DU-08-L1	Lysimeter	16.1	K	04/17/02	04/29/02	Logger	NA	N
DU-08-L2	Lysimeter	14.1	K	04/17/02	04/29/02	Logger	NA	N
743-03-L1	Lysimeter	12.8	NA	04/17/02	04/29/02	0 cb	NA	N
743-03-L2	Lysimeter	9.8	NA	04/17/02	04/29/02	0 cb	NA	N
743-08-L1	Lysimeter	23.3	K	04/17/02	04/29/02	Logger	NA	N
743-08-L2	Lysimeter	9.0	NA	04/17/02	04/29/02	5 cb	NA	N
743-18-L1	Lysimeter	12.1	NA	04/17/02	04/29/02	32 cb	NA	N
743-18-L2	Lysimeter	12.8	NA	04/17/02	04/29/02	26 cb	NA	N
SVR12-1-L1	Lysimeter	11.1	K	04/17/02	04/29/02	Logger	NA	N
SVR12-1-L2	Lysimeter	5.8	NA	04/17/02	04/29/02	4 cb	NA	N
Pit5-TW1-L1	Lysimeter	12.2	NA	04/17/02	04/29/02	2 cb	NA	N
Pit5-4-L 1	Lysimeter	10.6	NA	04/17/02	04/29/02	0 cb	NA	N
741-08-L1	Lysimeter	15.2	NA	04/17/02	04/29/02	32 cb	IPL0570 13A	YES=~20 mL
741-08-L2	Lysimeter	7.8	NA	04/17/02	04/29/02	0 cb	NA	N

* = based on vacuum data recorders

Table E-2. Operable Unit 7-13/14 Probing Project Type B probe sample summary table.

Sample Order *	Probe Location	Probe Type	Probe Depth (ft)	Data Logger #	Date Vacuum	Start Pressure	End Pressure*	Date Vacuum Tank	Date Sampled	Sample ID	Lysimeter Water (Y or N)	Sample Volume	Final Vacuum at Sample
Quarterly Sampling (Summer 2002)													
18	DU-10-L1	Lysimeter	9.8		8/6/2002	0	15 Hg	8/6/2002	8/22/2002	NA	N	NS	0 (tank)
17	DU-10-L2	Lysimeter	7.0		8/6/2002	0	15Hg	8/6/2002	8/22/2002	NA	N	NS	0 (tank)
13	DU-14-L1	Lysimeter	16.0		8/6/2002	0	15 Hg	8/6/2002	8/22/2002	NA	N	NS	4 (tank)
14	DU-14-L2	Lysimeter	7.9		8/6/2002	0	15 Hg	8/6/2002	8/22/2002	NA	N	NS	8 (tank)
15	DU-08-L1	Lysimeter	16.1		7/30/2002	0	15 Hg		8/22/2002	NA	N	NS	Data
16	DU-08-L2	Lysimeter	14.1		7/30/2002	0	15 Hg		8/22/2002	NA	N	NS	Data
8	743-03-L1	Lysimeter	12.8		8/6/2002	0	15 Hg	8/6/2002	8/21/2002	NA	N	NS	8 (tank)
7	743-03-L2	Lysimeter	9.8		8/6/2002	0	15 Hg	8/6/2002	8/21/2002	NA	N	NS	0 (tank)
3	743-08-L1	Lysimeter	23.3		7/30/2002	0	12 Hg		8/21/2002	NA	N	NS	Data
4	743-08-L2	Lysimeter	9.0		7/30/2002	0	15 Hg		8/21/2002	NA	N	NS	Data
6	743-18-L1	Lysimeter	12.1		7/22/2002	0	15 Hg		8/21/2002	NA	N	NS	Data
5	743-18-L2	Lysimeter	12.8		7/30/2002	0	15 Hg		8/21/2002	NA	Y	<1 mL	Data
1	SVR12-1-L1	Lysimeter	11.1		8/6/2002	0	15 Hg	8/6/2002	8/21/2002	NA	N	NS	0 (tank)
2	SVR12-1-L2	Lysimeter	5.8		8/6/2002	0	15Hg	8/6/2002	8/21/2002	NA	N	NS	0 (tank)
9	Pit5-TW1-L1	Lysimeter	12.2		7/30/2002	0	15 Hg		8/21/2002	NA	N	NS	Data
10	Pit5-4-L1	Lysimeter	10.6		8/6/2002	0	15Hg	8/6/2002	8/21/2002	NA	N	NS	0 (tank)
11	741-08-L1	Lysimeter	15.2		7/22/2002	0	15 Hg		8/21/2002	IPL077013A	Y	~20 mL	Data
12	741-08-L2	Lysimeter	7.8		8/6/2002	0	15Hg	8/6/2002	8/21/2002	NA	N	NS	0 (tank)
Quarterly Sampling (Fall 2002)													
18	DU-10-L1	Lysimeter	9.8	18	10/24/02	0	10	10/24/02					
17	DU-10-L2	Lysimeter	7.0	10	10/24/02	0	7.5	10/24/02					
13	DU-14-L1	Lysimeter	16.0	13	10/24/02	0	13.5	10/24/02					
14	DU-14-L2	Lysimeter	7.9	20	10/24/02	0	14	10/24/02					
15	DU-08-L1	Lysimeter	16.1	12	10/24/02	0	14	NA					
16	DU-08-L2	Lysimeter	14.1	27	10/24/02	0	14.5	NA					
8	743-03-L1	Lysimeter	12.8										
7	743-03-L2	Lysimeter	9.8										
3	743-08-L1	Lysimeter	23.3										

Table E-2. (continued).

Sample Order *	Probe Location	Probe Type	Probe Depth (ft)	Data Logger #	Date Vacuum	Start Pressure	End Pressure*	Date Vacuum Tank	Date Sampled	Sample ID	Lysimeter Water (Y or N)	Sample Volume	Final Vacuum at Sample
4	743-08-L2	Lysimeter	9.0										
6	743-18-L1	Lysimeter	12.1										
5	743-18-L2	Lysimeter	12.8										
1	SVR12-1-L1	Lysimeter	11.1										
2	SVR12-1-L2	Lysimeter	5.8										
9	Pit5-TW1-L1	Lysimeter	12.2										
10	Pit5-4-L1	Lysimeter	10.6										
11	741-08-L1	Lysimeter	15.2										
12	741-08-L2	Lysimeter	7.8										

ID = identifier

NA = not applicable

NS = no sample collected (attempted, but no media to fill container)

* = Based on vacuum data recorders

Yellow highlight indicates historic samples.